Implementation of Triple Helix Clusters Procedure in the sub-Sahara Africa Energy Sector

Case Study: Academia - CREEC Photovoltaic Laboratory

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Abstract

Penetration of decentralized power supply for households and commercial enterprises is low in Sub-Sahara Africa. Solar Home Systems (SHS), despite their widespread use in other continents have failed to attain much success in Africa. One of the reasons is the high rate of failure of existing implementations. Data shows earlier failure rates of 50%.[1] This is largely attributed to poor quality of products used, inefficient installation, mismanagement and lack of maintenance. To address this problem, the Centre for Research in Energy and Energy Conservation (CREEC) is setting up a Solar PV test laboratory in Uganda. This paper describes the installation process and how to sustain the laboratory after implementation. The lab is intended to provide a forum for training, research and consultancy under CREEC. It is intended as a tool to implement the triple helix and clusters procedure in the PV industry in particular and the energy sector in a more general scope. This paper offers details covering the current situation of the energy sector in Uganda and how the lab supports capacity building in the university to support the upcoming demand.

Keywords: Solar home system, Renewable energy, Test laboratory, PV training, Clusters; Rural development, PV market.

Introduction

Uganda is endowed with good insolation levels practically the whole year round ranging from 4000 to 6000 Wp/m^2/day. The national grid covers less than 10% of the urban population and less than 3% of the rural one. Despite this scenario, PV technology has not managed to penetrate and the PV industry is small and financially weak in the country.

The government is making an effort to further its dissemination but the results are rather meagre. The Ministry of Energy and Mineral Development (MEMD), Rural Electrification Agency (REA), Private Sector Foundation Uganda (PSFU) are the units receiving funds from the World Bank under the Energy for Rural Transformation (ERT) project phase II to tackle the problem.

Development agencies such as Sida, GIZ, and NORAD have availed extra funds in one way or another to strengthen the PV industry under the Renewable Energy Agenda.

The Private Sector has been improving steadily though on a small scale and lately has organised itself under the Uganda National Renewable Energy Association (UNREA). Leading academia's efforts, CREEC at the College of Engineering, Design, Art and Technology (CEDAT), Makerere University is creating capacity at technical, degree, masters and PhD level. With the support of the above-mentioned development agencies a Masters in Renewable Energy has been established at CEDAT with four specializations: bioenergy, micro-hydro, solar PV and energy efficiency in the building environment supported by NORAD. Sida has given close to 10 million dollar in a five years project to build capacity at PhD level with a total of 30 plus candidates. Four of them are conducting research in renewable energy. GIZ has sponsored quite a number of PV related projects and (with the support of German private companies) has provided CREEC with three PV systems for demonstration and training (1050 Wp, 330 Wp and a DC fridge system 185 Wp). It is within this framework that Sida availed 150 thousand USD for solar PV laboratory equipment.

Triple Helix Approach

Despite the reliability of the PV technology, the support of the government, the willingness and good will of the private sector and the ability of the academia to handle applied research in this field, PV power as a percentage of total power consumed in Uganda is practically negligible at less than 1%.

This is mostly because there is not a coordinated effort by the three players government, private sector and academia to put their potential in a concerted manner to achieve the goal of widespread use of solar energy in Uganda. The solution for this problem could perhaps be the implementation of the so called "triple helix" or clusters initiative.

To understand better the triple helix concept we list below three citations:

At the moment, one unsatisfactory element in the European system has been that the linkages between university and industry, research and business world are not strong enough. Moving towards the knowledge-based society, however, also means that boundaries between public and private, science and technology, university and industry are blurring as the distribution of research locations becomes a key factor of economic growth in a

[1] GIZ-PREEEP studies: Impact assessment of the Solar Electrification of Health Centres and Impact assessment of the Solar Electrification of Micro Enterprises, Households and the Development of the Rural Solar Market, both in 2009

knowledge-based economy. Knowledge has become to a growing extent a potential product that can be exploited on the market, which means the industrialisation of the production of scientific knowledge.[2]

Universities and firms are in growing extent assuming each other's tasks, and, as the university crosses traditional boundaries in developing new linkages to industry, it has to devise the connections between research, teaching, and economic development. Within industry, questions are raised about what should be located inside the firm, between firms, or among firms, universities, and government institutions. Are the firms willing to support basic research or is better to leave this task to the universities? What is the role of government given the need for technological innovation in international, national and regional development?.[3]

This mode of thinking - referred as 'triple helix' - is beneficial especially for the 'hard sciences', in which basic and applied research can be organised according to the triple helix model. However, in the field of humanities and social sciences, anything comparable to the technology centres has not yet been established, even though there are some efforts in that direction. Today the life sciences are a good example of a field where the co-operation between state, universities and a specific industrial cluster is a prerequisite for generating innovations. Universities are needed for the basic research, and they collaborate in R&D with the enterprises for the development of practical applications in specially designed environments (science parks etc.) funded largely by national governments but extracting also a lot of other funding. These installations have the capacity to employ a large amount of experts with postgraduate qualifications in different disciplines.[4]

An example of a successful triple helix implementation is Silicon Valley, where the government has provided land, financing mechanisms, tax holidays and suitable policies to allow the private sector to thrive - in this specific case on the IT industry.

On its side, the private sector (Dell, HP, Oracle, Intel, Microsoft, etc) do what they know best, which is production of reliable computers and software produced in a sustainable and efficient manner.

The very needs of the industry, powered by the created market, generate the need for the academia which in this case comprises of ICT professionals who are given all facilities to do R&D and product development to further boost the industry.

Government, industry and academia all profit as taxes are collected on sales of goods, revenue is generated and knowledge is developed within a suitable research environment.

Nevertheless, this is not the whole story. The greatest beneficiaries of this cluster program are the consumers who can buy good and reliable computers - tools to empower them as individuals and provides a platform for them to play a meaningful role in society.

This comparison of solar PV dissemination in Africa with Silicon Valley may look a bit farfetched but it is not. Actually any business can be implemented using the triple helix concept. It is replicable and up-scalable.

As a matter of fact, there is a project sponsored by Sweden to start 1000 different clusters in Africa. It is called "Lighting 1000 cluster fires by 2010".[5]

This shows that the dissemination of solar PV equipment for decentralized power supply in Africa can very well benefit from this triple institutions business approach. What follows in this study is a description of the three "partners" meant to change the face of Africa in terms of renewable energy utilization and people's living standards. We shall start by describing the unit in charge of knowledge management, innovation creation and validation of product which we call generically academia. This will be followed by details on the Government of Uganda and finally the private sector.

CREEC

The Centre for Research in Energy and Energy

Conservation is a research, consultancy and training organisation based at the College of Engineering, Design, Art and Technology (CEDAT), Makerere University. CREEC was founded in 2001 with the goal of developing into a centre of excellence in energy for Uganda and the entire East African Region.

Its goal is to create capacity in all fields related to energy with a special focus on the following areas:

- Energy management
- Pico hydropower
- Solar photovoltaic (PV)
- Bioenergy

Its aim is to develop technologies and systems that have a direct, positive impact on people's everyday lives. Along these lines, CREEC promotes technology transfer from researchers to society through pilot project implementation, training programmes and public awareness initiatives. This is done in order to bridge the missing link between researchers, the business community, funding agencies and the general public.

CREEC has a threefold mission:

- Research – The centre has access to experts in the various fields of energy at PhD level. It participates in regional and international research initiatives, such as joint Master and PhD projects with renowned universities abroad.
- Training – CREEC offers training courses to professionals who wish to improve their practical knowledge in photovoltaic installation, pico-hydro systems, bioenergy and energy

[2] Etzkowitz, H. & Leydesdorff, L. 1995: The Triple Helix: University - industry - government relations. A laboratory for knowledge based economic development. *EASST Review. European Society for the Study of Science and Technology 14*(1): 18-36.

[3] Jacob, M. 1997: Life in the Triple Helix: The contract researcher, the university and the knowledge society. *Science Studies 10*(2): 35-49.

[4] Ziman, J. 1994: *Prometheus Bound: Science in a dynamic steady state*. Cambridge University Press. Cambridge U.K. From http://finhert.utu.fi/ruse/helix.htm

[5] http://www.tci-network.org/news/card/208

management. Furthermore, CREEC's director, Dr. Izael Pereira da Silva, is the coordinator of the MSc Degree Programme in Renewable Energy in cooperation with the Norwegian University of Science and Technology (NTNU).

- Consultancy – Apart from energy auditing, experienced staff offers expertise on energy policy, small-scale energy project implementation, rural electrification programs and others.

Among many smaller projects, CREEC is currently implementing two large renewable energy projects:

1. Dissemination of energy efficient stoves:
CREEC won a grant from the World Bank's Biomass Energy Initiative for Africa (BEIA) to develop, produce and disseminate energy efficient stoves. In collaboration with Prof. Paul Anderson from the U.S. CREEC will promote the existing TopLit UpDraft (TLUD) stove, which will be produced locally and disseminated in rural Uganda. Supported by GIZ, a facility called Bioenergy Research Centre has been established that is well equipped to conduct biomass research. For example, CREEC owns the only Portable Emission Measurement System (PEMS) in Africa; this is being used to measure emissions from cookstoves.

2. Millennium Science Initiative (MSI):
Dr. Izael Pereira da Silva, CREEC's director, is the Principal Investigator of the interdisciplinary research project "Rural Electrification in Uganda Increasing Access to Modern Types of Energy" which is sponsored by the Uganda National Council for Science and Technology (UNCST). This research project focuses on the implementation of renewable energy systems, GIS mapping and business modelling. Because CREEC is linked to Makerere University and thus has at its disposal a large number of lecturers, undergraduate and graduate students, it can develop the role of knowledge management and capacity building to strengthen the renewable energy sector not only in Uganda but also in the whole of East Africa.

CREEC's PV Laboratory
Many solar laboratories have been built in Africa but most of them have failed because technicians were not familiar with equipment and/or because income generating activities were not defined as a critical output of the laboratories. In order to avoid this, CREEC plans to establish cooperation with the Government of Uganda and solar PV dealers to create business for the lab. This is done on the spirit of collaboration mentioned above. Possible ways to sustain the lab are:

– Cooperation with the Uganda National Bureau of Standard (UNBS) to set up standards to be met by solar products entering the country. Use the laboratory to do labelling on their behalf. Labelling has been a very effective tool to enforce standards and fight counterfeit items coming into the market.
– Charging for independent solar PV equipment testing and consultancy for importers who wish to test prototypes/samples of equipment they plan to sell to the Ugandan market.
– Offering our practical expertise to train engineers at undergraduate and graduate levels to fill the market need.
– Train technicians from the private sector in all matters pertaining PV design, installation and maintenance
– Ensure the quality label of Lighting Africa by using Lighting Africa's test procedures and standards to test solar lanterns (pico-PV products)

Besides these activities CREEC will be able to generate income through the services rendered by the laboratory when it is used to provide tests to projects such as the one sponsored by the World Bank and the Uganda National Council for Science and Technology.

The initial set of equipment that the lab is acquiring is listed below:

- Luxmeter
- Photometer box
- Integrating Sphere with photometer
- Set calibration lamps
- Spectrophotometer with optical fiber
- DC supplies
- Multimeter
- Datalogger
- Battery charging and analyzing device
- PV module analyzer

Using the procedures developed by Fraunhofer ISE during the lamp-test with GIZ and published under Lighting Africa and quoted in MICRO ENERGY international[6], the laboratory will be able to support implementation of Solar Home Systems (SHS) through:

- Demonstrating SHS Evaluating the quality of the whole SHS configuration e.g. checking how many Watt a panel actually delivers
- Unmasking illegal imitation systems
- Confirming manufacturers stated specifications
- Designing the system's configuration

Another goal for the laboratory is to set up a global network with other test facilities such as Joint Research Centre (JRC) in Ispra - Italy. Furthermore, the laboratory can be used to:

- Simulate different users' profiles
- Collect information about the long-term performance of SHS
- Compare the performances of different system configurations e.g. change the different load appliances, batteries, charge controllers and solar panels
- Check the potential effects on the systems of some uncommon usage practices e.g. bridging the battery

[6] The concept of solar home systems test facility; unpublished material. MICRO ENERGY international (www.microenergy-international.com)

The local test facility has to have the following features:

- It should be built of robust components
- The set-up and the operation should be clear to local technicians
- It can be used for training local technicians
- Running costs should be covered by its activity (cost-recovery approach)
- Check the performance of the whole SHS system as well as separate components
- Data analysis should be in line with international procedures
- Autonomous power supply to run the logging unit, especially to operate in the off-grid areas and the areas of unstable grid

An additional target of the laboratory is to involve electrical engineering students from CEDAT to work under the supervision of trained personnel in practical activities to enhance their training and awareness regarding renewable energy in general and solar PV technologies in particular.

This will definitely have a positive impact on the solar market in Uganda and is a typical win-win situation as students can work for small pay and thus help reducing the laboratory operational costs.

CREEC has an agreement with the CEDAT through which the college avails the centre with space, electricity, internet, water and security for free, further helping the lab to be self-sufficient.

Case study: first tests done by the laboratory

CREEC tested a solar system which was assembled in Uganda with as much local products as possible. These lights are meant to be sold in the rural and peri-urban areas and are designed to target the poor in those areas.

The LED lamps are also designed to be assembled where there is no access to electricity. For instance, the connections are made in such a way that they do not need soldering. A plastic bottle head forms the lampshade and works as the container for the electronic parts. The LEDs are inserted in a cushion covering the lamp.

This is a seemingly excellent idea of a product built by the poor for the poor without compromising quality. For this reason the manufacturer asked CREEC to test the prototype.

CREEC's test methodology focused on following measurements:

- Battery Discharging Test versus Lumen Output
- The discharging curves from the manufacturer's datasheet were verified by measuring the battery voltage drop over time while the lamp was switched on. During this experiment, the battery voltage and the current were continuously measured by data loggers. The lamp was lit inside of a dark box within which a light meter (luxmeter) measured light intensity. The measurement started with fully charged batteries and lasted until the battery was fully discharged.
- Charging test
- The battery voltage and the power provided by the PV panel during charging by sunlight were measured. The idea was to find out how long it would take for the battery to be fully charged under several insolation conditions.
- Comparative Light Output test
- The light output of the lamp was measured and compared to the light output of a kerosene lamp and also a wax candle.
- IP rating test
- The degree of protection in accordance with EU standard DIN EN 60529 was used as a measure for the safety of the system.

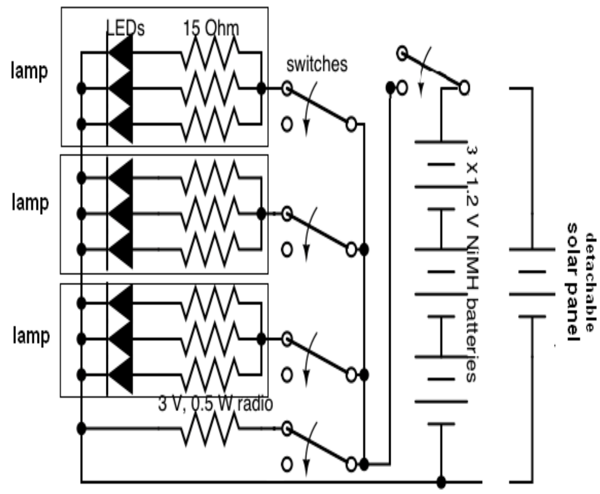

Figure 1: Wiring Diagram of the LED lamp

The results of the test and the recommendations provided by CREEC can be used by the manufacturer to enhance dissemination of the product and to further improvements of the product.

This example shows clearly how a laboratory in Africa can help private sector people to test their products not only with regards to the technical aspects but also to show them which measures to take to provide the market with a successful product.

In the near future CREEC has plans to cooperate with UNBS to be able to test and label solar PV equipment on behalf of their institution.

Performance test of PV System

CREEC was granted a solar PV system of 1050 Wp with a 600 Ah 24 V battery bank (14.4KWh). In January 2010 the control system was showing power available (SoC) at about 50% of the expected and the weather was sunny with almost no clouds.

The load attached to the system was way below its nominal size and there were no losses in cables or connections as the panels are at a maximum 5 meters from the battery bank which is about 5 meters from the load.

This became a puzzle which CREEC personnel took upon themselves to solve. Tests on each of the components were performed and it was found that the output from the six 175 Wp panels were not the expected. A visual inspection of the panels showed no defective parts nor stains which could have accounted for the weak output.

One of the most conventional modes of installation of solar panels in Uganda is to secure them with an angle L shaped iron frame to prevent theft. It so happened that in this case the frame was not tightly attached to the panels and was thus creating shadow on a whole set of cells of the panels (see picture below).

A simple reduction of the size of the frame and a support placed under the panels resolved the problem totally. This is a typical issue which, left unchecked would make people in NGOs, users and even in government to come to the wrong conclusion that solar PV systems do not work in our region.

Again, the presence of well trained personnel with a set of well suited tools made it possible to solve this problem. CREEC has since then tried to disseminate this information so that all stakeholders are aware of this possible problem when installing solar PV systems.

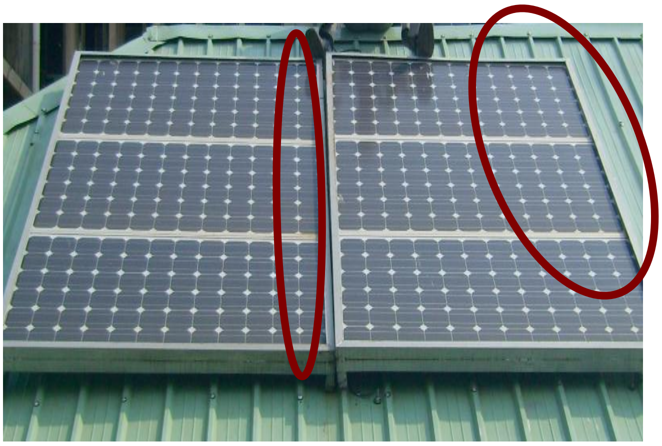

Figure 2: Shadow at 3 pm due to the unsuitable frame

The Government of Uganda

The Ministry of Energy and Mineral Development (MEMD) is very supportive of initiatives that foster the use of renewable energy.

Uganda is actually considered the most innovative country in the entire East Africa region when it comes to the electricity sector regulation. Things started changing in 1999 when Parliament approved the Electricity Act [6] by which the government monopoly of generation, transmission and distribution of electricity ceased. ESKOM manages the generation, transmission remained a government managed company (Uganda Electricity Transmission Company Ltd) and distribution was privatized and is now managed by a number of different companies. UMEME, which handles more than 90% of the power distribution in Uganda, is the biggest one in this field.

The government has published the Energy Policy Act[7] in 2002 and the Renewable Energy Policy[8] in 2007.

With the support of the World Bank it has established the Rural Electrification Agency (REA) to manage funds as well as implement and supervise activities aiming at provision of energy to rural areas (www.rea.or.ug).

One of the most important decisions of the government towards the dissemination of solar PV power systems in the country was the waiving of all taxes on importation of solar PV equipment. Even VAT was scrapped making these items a lot more affordable to the consumers.

From a capacity building view point the Government of Uganda has also created a department for Renewable Energy in the Ministry of Energy being run under a commissioner.

Following a decentralization trend the Ministry of Energy has also created a post of District Energy Officer. This position is to hold the portfolio of supporting at district level all projects and initiatives related to energy, rural electrification, and income generating programs using renewable sources of energy.

Lastly, the Uganda National Bureau of Standards (UNBS) has been working on setting up standards to avoid the proliferation of poor quality solar PV equipment in the market. This para-governmental institution has received support from development agencies to set up laboratories and to work on bringing their testing facilities to international levels, especially the ones related to electrical equipments.

One of the things which, although already spelt out in the Renewable Energy Policy document in 2007, has being set for implementation in November 2010 as per the document: "Uganda Renewable Energy Feed-in Tariff (REFIT); Phase 2; Guidelines 2010; Draft V4; 1st November 2010"[9] is the feed-in-tariff for solar PV which has the government committed to pay USD 0.326 per kWh of solar PV generated energy up to a maximum of 2 MW.

As can be seen, the role government can play for the creation or strengthening of the energy sector is essential and without this player sustainable growth cannot be realised.

The private sector

Uganda's GDP ranks amongst the smallest in the whole world. Even when compared with other African countries it does not fare any better. More than half of the population live under the poverty level on less than one dollar a day. Recently, Uganda and four neighbouring countries (Kenya, Tanzania, Rwanda and Burundi) joined the East African Community, allowing free movement of people and goods. This brings some hope to the solar PV industry as the almost 130 million people in these five countries can make competitive importation of solar PV equipment from Europe and the USA more affordable.

Added to that, we recently had the birth of a new country with the split of Sudan into North and South Sudan. The newly created South Sudan with a population close to 10 million is a new market which will naturally be added to the East African Community one.

[7] Available on: www.era.or.ug/Pdf/Electricity_Act.pdf
[8] The Energy Policy for Uganda, Ministry of Energy and Mineral Development, 2002. Available on: www.rea.or.ug/userfiles/EnergyPolicy%5B1%5D.pdf

[9] The Renewable Energy Policy for Uganda, Ministry of Energy and Mineral Development, 2007.Available on: www.rea.or.ug/.../RENEWABLE%20ENERGY% 20POLIC9-11-07.pdf

In this study we consider more specifically the Ugandan situation but Kenya and Tanzania have a greater market of solar PV than Uganda.

In Uganda the solar PV dealers have organised themselves in an association called UNREA.

UNREA

The Uganda National Renewable Energy Agency Limited (UNREA) is a confederation / association of Ugandan private companies dealing in distribution of solar PV and other renewable energy technologies in Uganda. It was incorporated in 2009 and has 10 reliable solar PV dealers in Uganda as members:

1. Energy Systems Limited.
2. Power & Communications Systems Limited.
3. Solar Energy Uganda Limited.
4. Incafex Solar Power Systems Limited.
5. Konserve Consult Limited.
6. Ultra Tec Uganda Limited
7. Power Options Limited
8. Solar Energy For Africa Limited
9. Battery Masters Limited
10. Mark Impex (U) Limited

Its mission and work is defined as: "…an autonomous private sector based stakeholder and participant in the general energy sector pursuing realistic promotion, development, and deployment of sustainable clean renewable energy solutions by promoting, coordinating, demonstrating, financing, disseminating and influencing energy delivery policies, protect energy consumers, promoting private sector sustaining investment in energy delivery services in Uganda".[10]

The core work of UNREA is to play a leading role in pursuing balanced rural electrification based on sustainable utilization of solar energy and other renewable energy resources in Uganda. UNREA is the strategic all-round working interface for the renewable energy sector.[11]

Though the volume of trade is still small, UNREA is determined to become a very important player in the renewable energy sector as government provides suitable taxation schemes and channels funds from development agencies towards the private sector via mechanisms such as Public Private Partnership (PPP) where government entrusts to the private sector activities such that the outcome can be counted as government achievement in the energy sector.

PSFU

The Private Sector Foundation Uganda (PSFU) is also playing a very important role as a government organ with the function of supporting the private sector. They have received support from the World Bank under the Energy for Rural Transformation (ERT) project and have availed the business community with grants up to 50% to cover consultancy and market survey to provide a smooth start to business.

It is not the mission of this paper to delve into the activities of PSFU but a visit on their website will show the tremendous impact they are having in the energy sector under the above mentioned ERT project.

Currently CREEC has a Memorandum of Understanding with PSFU to work in three areas, namely: solar PV, small hydro-power and energy efficiency. Under this last one CREEC is expected to do verification and evaluation of the creation of a 10 MVA Virtual Power Station (VPS) made up of savings from energy efficient projects from at least 50 industries.

Conclusions

Although all three partners for the triple helix system are already in place in Uganda, we are yet to start working in a more systematic manner together.

We have the opinion that rather than designing great schemes, the right path is to start doing some projects in cooperation and to widen little by little the scope of this clusters cooperation upon verifying the success of the venture.

As can be seen by the two sample activities performed at CREEC's lab, the initiative can help all solar PV industry stakeholders. As mentioned above, government has created the position of a District Energy Officer to handle matters pertaining especially renewable energy at district level. Currently there are close to 100 districts in Uganda. So, practical training in our facilities would go a long way to produce the right people to take over these responsibilities and thus help penetration of renewable energy technologies into rural Uganda. For the private sector the test laboratory at CREEC can provide short term training to get technicians able to install reliable systems from SHSs to large institutional ones. Finally, for the academia this is a perfect place to give engineers hands on experience which sometimes is lacking in many high level training institutions in sub-Sahara Africa.

All the possible activities of the solar PV laboratory at CREEC have as their overall goal to support the growth of the solar PV market in Uganda and provide solutions for the energy needs of people in rural areas using the concept of decentralized renewable energy power supply. Once fully installed the lab will play a relevant role in setting up a renewable energy cluster in Uganda and the East African region able to emulate the success of Silicon Valley.

[10] "Uganda Renewable Energy Feed-in Tariff (REFIT); Phase 2; Guidelines 2010; November 2010" yet to be implemented is the feed-in-tariff for grid connected PV systems. Available on: www.era.or.ug/.../Approved_Uganda%20REFIT%20Guidelines%20V4%20(2).pdf

[11] UNREA – Memorandum of the company, 2009